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# Computational aeroacoustic study of a landing gear

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Computational study of a single wheel landing gear configuration was completed to understand the noise source and it's nature. The flowfield visualisation showed the present of large structural shedding in the wake side of the the landing gear wheel. These large structures were responsible for the low frequency noise. Spectral peaks at frequencies lower than 200 Hz were found to exist from the analysis of the frequency content of the pressure signals at farfield. These low frequency peaks were due to the large structural shedding.

## 1 Introduction

Aerodynamic noise from landing gear is considered as a major source of noise in airframe noise study especially during landing when the engine is operating at low thrust. Numerous experimental as well as computational studies to identify the noise source and it's attenuation techniques are being carried out around the globe [1,2]. The landing gear acoustic spectra normally has a peak at mid to low frequencies and is considered to be an important source of noise for modern passenger aircrafts such as Airbus A380 Boeing 787. Flow over the large elements such as wheels is found to be responsible for low frequency noise whilst small components such as axles, struts, wires etc are responsible for the noise at high frequencies. Streamlined fairings are being used to reduce the high frequency noise. However, streamlining the wheel is not possible and hence the wheel is thought to be the most challenging noise source in airframe noise. The work of Heller *et al.* found that multiple-wheel configurations to be noisier than single-wheel configuration [3]. This work investigates the aerodynamic noise radiation from a single wheel configuration.

## 2 Solution Approach

This work involved mainly computational study of the problem. The computational solver used in this study is based on the finite difference scheme and is a high-order computational aeroacoustic (CAA) solver developed by the author which solves the Navier-Stokes equations in conservative form. It uses a fourth-order optimized compact finite difference scheme for spatial derivatives [4] and the explicit, low-storage Runge-Kutta scheme of Hu *et al.* [5] to advance the solution in time. Several test cases including both inviscid and viscous flow have been used to validate the CAA code. Several options of turbulence models are available in the solver including one equation and two equation models. For the 3D simulations, the hybrid/RANS variant of one equation SA model [6] is also available.

Several computational studies in the past have experienced a limitation with Reynolds-averaged NavierŰStokes (RANS) and turbulence models applied to unsteady flows [6,7]. The RANS solver produces increased eddy viscosity which causes excessive damping of the unsteadiness of the flowfield. This is due to the assumption in the RANS turbulence model that all scales of the unsteady motion are to be captured and modelled by it. Spatially filtered models such as Large-Eddy Simulation (LES) have provided improved results for simulating unsteady flows. LES models, however, are currently limited to low Reynolds numbers because of the computing resources required to resolve the small-scale turbulent structures. LES is, therefore, not a feasible tool yet for the study of cavity flowfields at transonic speeds. Recently, hybrid methods which behave as a standard RANS model within the attached boundary layer and as a LES Sub-Grid Scale model in the rest of the flow, including the separated regions, have been introduced to address this problem [6]. Flow simulation with a turbulence model based on such a hybrid method is used in this study.

## 3 Results and Discussions

The landing gear geometry considered in this investigation was a single wheel configuration. Figures 1-3 show the wheel geometry and structured grid distributions. Multiblock structured grid was created to compute unsteady flowfield around the wheel. Figures 4 and 7 show the instantaneous iso-surfaces of vorticity magnitude and the second invariant of the velocities around the wheel. The presence of large vortex structures can clearly be seen from the figures. To study the unsteady flow quantitatively, the frequency contents of the farfield (at a distance of 100m from the centre of the wheel) pressure signals were extracted using fast fourier transforms. From the Figures 5-6 and 8-9, it is evident that dominant acoustic peaks occur in low frequencies (less than 200 Hz) for all the cases. Low frequency peaks are expected when there is a flow around large components in this case, the wheel. However, No peaks are seen to exist in higher frequencies (greater than 200 Hz). This is also expected as the landing gear model in this case did not have any small components e.g. axle, hub cut outs etc which are responsible for the high frequency noise.

## 4 Concluding Remarks

Flow around a landing gear wheel results in large structural sheddings. These large structures in fact are the sources of low frequency noise. Hence the wheels contribute towards the low frequency noise of the landing gear.

## Acknowledgements

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## References

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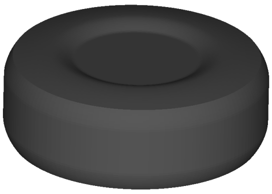

Figure 1: CAD model

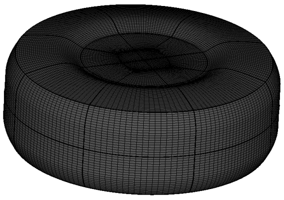

Figure 2: Structured surface grid

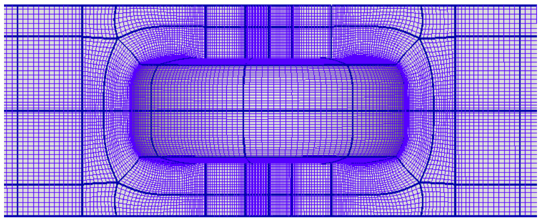

Figure 3: Structured near field grid design around the wheel.

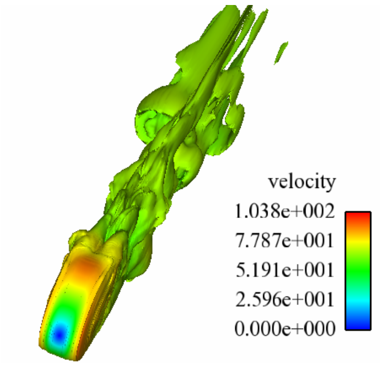


Figure 4: Iso-surface of vorticity

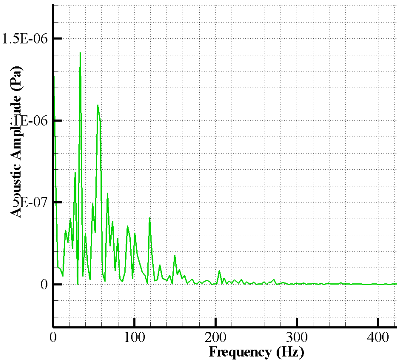


Figure 5: Acoustic signal directly above the wheel

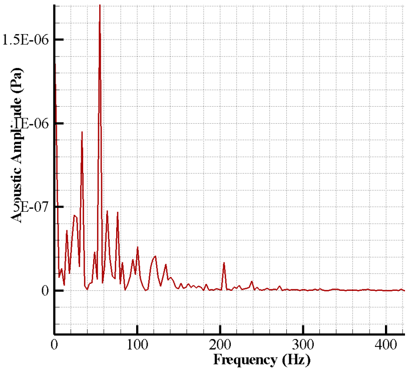


Figure 6: Acoustic signal directly below the wheel

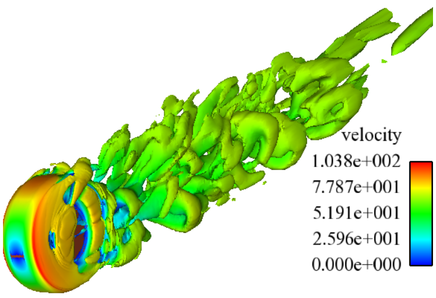


Figure 7: Iso-surface of second invariant of velocity

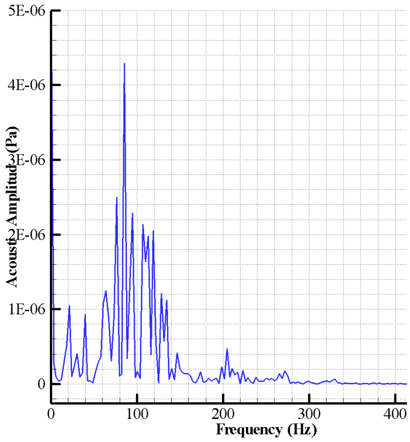


Figure 8: Acoustic signal at upstream of the wheel

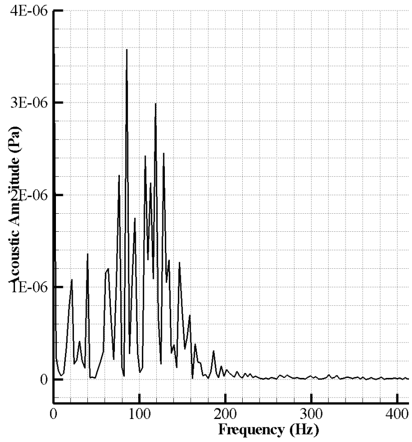


Figure 9: Acoustic signal downstream of the wheel